

## CLAIMS

What is claimed is:

- 1     1.     An apparatus comprising:  
2           a network element to be coupled to a first and second span of a plurality of  
3           spans that interconnect a set of network elements to form a ring network,  
4           each of said plurality of spans having two sub-spans on which traffic  
5           travels in opposite directions on a plurality of channels that circumvent  
6           said ring, each said plurality of channels including working channels and  
7           protecting channels, said network element including,  
8           a traffic handler to reprogram, responsive to protection switches and un-  
9           switches, the connection configuration on the protecting channels  
10          of the sub-spans of the first and second spans that provide traffic  
11          to the network element.
- 1     2.     The apparatus of claim 1, wherein, responsive to a protection switch, two  
2           different connection configurations are programmed on the protecting channels of the  
3           sub-spans of the first and second spans that provide traffic to the network element.
- 1     3.     The apparatus of claim 1, wherein, responsive to a protection switch, the same  
2           connection configuration is programmed on the protecting channels of the sub-spans of  
3           the first and second spans that provide traffic to the network element.
- 1     4.     The apparatus of claim 1, wherein, responsive to a protection un-switch, two  
2           different connection configurations are programmed on the protecting channels of the  
3           sub-spans of the first and second spans that provide traffic to the network element.
- 1     5.     The apparatus of claim 1, wherein, responsive to a protection un-switch, the  
2           same connection configuration is programmed on the protecting channels of the sub-  
3           spans of the first and second spans that provide traffic to the network element.
- 1     6.     The apparatus of claim 1, wherein said traffic handler includes a connection  
2           table generator to communication connection configuration information with others of  
3           said plurality of network elements.

1 7. The apparatus of claim 1, wherein said ring network is a modified bi-direction  
2 line switched ring.

1 8. The apparatus of claim 1, wherein said network element further includes:  
2 a first set of structures to store the connection configurations programmed on  
3 the working and protecting channels of the sub-spans of the first and  
4 second spans that provide traffic to the network element; and  
5 a second set of structures to store the connection configurations programmed on  
6 the working channels of those of said plurality of spans not directly  
7 connected to the network element.

1 9. An apparatus comprising:  
2 a network element coupled to a first and second span of a plurality of spans that  
3 interconnect a set of network elements to form a ring network, each of  
4 said plurality of spans having two sub-spans on which traffic travels in  
5 opposite directions on a plurality of channels that circumvent said ring,  
6 each said plurality of channels including working channels and  
7 protecting channels, said network element including a machine readable  
8 medium having stored thereon instructions, which when executed by a  
9 set of one or more processors, cause said set of processors to perform  
10 operations including,  
11 storing in a first set of structures connection configurations for the  
12 working and protecting channels programmed on the receiving  
13 side of the ports coupled to the sub-spans of the first and second  
14 spans; and  
15 storing in a second set of structures the connection configurations  
16 programmed on the working channels of those of said plurality  
17 of spans not directly connected to said node.

1 10. The apparatus of claim 9, wherein said storing in said first set of structures  
2 includes storing one connection configuration for both of the working and protecting  
3 channels on the receiving side of both of the ports coupled to of the sub-spans of the  
4 first and second spans.

- 1 11. The apparatus of claim 9, wherein said storing in said first set of structures  
2 includes storing one connection configuration for each of the working and protecting  
3 channels on the receiving side of both of the ports coupled to of the sub-spans of the  
4 first and second spans.
- 1 12. The apparatus of claim 9, wherein said storing in said first set of structures  
2 includes storing one connection configuration for both of the working and protecting  
3 channels on the receiving side of each of the ports coupled to of the sub-spans of the  
4 first and second spans.
- 1 13. The apparatus of claim 9, wherein said storing in said first set of structures  
2 includes storing one connection configuration for each of the working and protecting  
3 channels on the receiving side of each of the ports coupled to of the sub-spans of the  
4 first and second spans.
- 1 14. The apparatus of claim 9, wherein said ring network is a modified bi-direction  
2 line switched ring.
- 1 15. The apparatus of claim 9, wherein said machine readable medium further  
2 includes:  
3 a traffic handler, to be coupled to said first and second set of structures, to  
4 reprogram, responsive to protection switches and un-switches, the  
5 connection configurations for the protecting channels programmed on  
6 the receiving side of the ports coupled to of the sub-spans of the first and  
7 second spans.
- 1 16. The apparatus of claim 9, wherein said machine readable medium further  
2 includes:  
3 a traffic handler, to be coupled to said first set of structures, to reprogram,  
4 responsive to protection un-switches, the connection configurations for  
5 the protecting channels on the receiving side of the ports coupled to of  
6 the sub-spans of the first and second spans; and  
7 said traffic, to be coupled to said second set of structures, to reprogram,  
8 responsive to protection switches, the connection configurations for the

9 protecting channels on the receiving side of the ports coupled to of the  
10 sub-spans of the first and second spans.

1 17. An apparatus comprising:  
2 a network element to be coupled to a first and second span of a BLSR ring, said  
3 network element including,  
4 means for providing different connection configurations on the  
5 protecting channels of said first and second spans responsive to  
6 protection switches and un-switches.

1 18. The apparatus of claim 17, where said means allows a first of said plurality of  
2 channels to be part of two different sized connections programmed on said first and  
3 second spans.

1 19. The apparatus of claim 17, where said means allows said first spans to have  
2 programmed thereon a concatenation of a plurality of the BLSR channels that is not  
3 programmed on said second span.

1 20. The apparatus of claim 17, wherein said means includes:  
2 a storage means for storing said different connection configurations; and  
3 a hardware control means for programming ports of said network element  
4 coupled to said first and second spans.

1 21. An apparatus comprising:  
2 a plurality of network elements;  
3 a plurality of spans interconnecting said plurality of network elements to form a  
4 ring, each of said plurality of spans having two sub-spans on which  
5 traffic travels in opposite directions;  
6 a multiplexing ring transport network protocol operating on said ring providing  
7 a plurality of channels on each of said sub-spans, each of said plurality  
8 of channels includes a set of working channels and a mutually exclusive  
9 set of protecting channels, wherein a first connection configuration  
10 programmed on a first of said sets of channels is not the same as a  
11 second connection configuration programmed on a second of said sets of  
12 channels.

1 22. The apparatus of claim 21, wherein said first set of channels and said second set  
2 of channels are respectively the set of working channels and the set of protecting  
3 channels on a same one of said sub-spans.

1 23. The apparatus of claim 22, wherein the same connection configuration must be  
2 programmed on each of said sets of working channels.

1 24. The apparatus of claim 22, wherein the same connection configuration must be  
2 programmed on each of said sets of working channels on which traffic travels in the  
3 same direction as said first set of channels, and wherein a third connection  
4 configuration is programmed on each of said sets of working channels on which traffic  
5 travels in the opposite direction as first set of channels, and wherein said first and third  
6 connection configurations differ.

1 25. The apparatus of claim 22, wherein the same connection configurations must be  
2 programmed on the set of working channels of both sub-spans of any given one of said  
3 spans, and wherein the connection configurations programmed on the sets of working  
4 channels of two different ones of said spans differ.

1 26. The apparatus of claim 22, wherein the connection configurations programmed  
2 on the sets of working channels of two different ones of said spans differ, and wherein  
3 the connection configurations programmed on the set of working channels of each of  
4 the sub-spans of at least one of said spans differ.

1 27. The apparatus of claim 21, wherein said first set of channels and said second set  
2 of channels are the sets of working channels on two different ones of said sub-spans.

1 28. The apparatus of claim 27, wherein said two different ones of said sub-spans are  
2 part of a same one of said spans.

1 29. The apparatus of claim 27, wherein said two different ones of said sub-spans are  
2 part of two different ones of said spans.

1 30. The apparatus of claim 27, wherein the same connection configuration must be  
2 programmed on each of said sets of working channels on which traffic travels in the  
3 same direction as said first set of channels.

1 31. The apparatus of claim 27, wherein the same connection configuration must be  
2 programmed on the set of working channels of both sub-spans of any given one of said  
3 spans.

1 32. The apparatus of claim 27, wherein said two different ones of said sub-spans are  
2 part of a same one of said spans, and wherein a third connection configuration is  
3 programmed on the set of working channels of a sub-span of a different one of said  
4 spans, and wherein said third connection configuration is not the same as said first  
5 connection configuration.

1 33. The apparatus of claim 21, wherein said multiplexing ring transport protocol is  
2 a bi-directional line switched ring protocol.

1 34. An apparatus comprising:  
2 a plurality of network elements;  
3 a plurality of spans interconnecting said plurality of network elements to form a  
4 ring, each of said plurality of spans including two sub-spans, said sub-  
5 spans forming two sub-rings, wherein a plurality of channels circumvent  
6 said ring on each of said sub-rings, each of said plurality of channels  
7 including working channels and protecting channels; and  
8 a traffic handler on each of said plurality of network elements that together  
9 reprogram the connection configurations of the protecting channels on at  
10 least certain of said sub-spans responsive to protection switches and un-  
11 switches.

1 35. The apparatus of claim 34, wherein said traffic handlers provide for different  
2 connection configurations on a per sub-span basis without mirroring.

1 36. The apparatus of claim 34, wherein said traffic handlers provide for different  
2 connection configurations on a per sub-span basis with mirroring.

1 37. The apparatus of claim 34, wherein said traffic handlers provide for different  
2 connection configurations on a per span basis with mirroring.

1 38. The apparatus of claim 34, wherein said traffic handlers provide for different  
2 connection configurations on a per span basis without mirroring.

1 39. The apparatus of claim 34, wherein said traffic handlers provide for different  
2 connection configurations on a per sub-ring basis with mirroring.

1 40. The apparatus of claim 34, wherein said traffic handlers provide for different  
2 connection configurations on a per sub-ring basis without mirroring.

1 41. The apparatus of claim 34, wherein the same connection configuration must be  
2 provided on the working channels of every sub-span, but said traffic handlers provide  
3 for a different connection configuration on the protecting channels.

1 42. The apparatus of claim 34, wherein each of said plurality of network elements  
2 includes:  
3 a first set of structures having stored therein the connection configurations  
4 programmed on the working and protecting channels of the sub-spans  
5 that provide traffic to the network element; and  
6 a second set of structures having stored therein the connection configurations  
7 programmed on the working channels of those of said plurality of spans  
8 not directly connected to the network element.

1 43. The apparatus of claim 34, wherein said ring is operated as a bi-directional line  
2 switched ring.

1 44. The apparatus of claim 34, wherein each of said network elements participates  
2 as a node of said ring, each node having stored therein the connection configuration  
3 programmed on the working channels of at least every one of said plurality of spans not  
4 directly connected to that node.

1 45. The apparatus of claim 34, wherein each of said traffic handlers includes a  
2 connection table generator to communication connection configuration information.

1 46. A method comprising:  
2 responsive to a failure in a span in a ring network, indicating a protection switch  
3 to occur on said ring network, wherein said ring network operates on a  
4 plurality of network elements that participate as nodes of said ring  
5 network and that are connected by spans to form a ring, each of said  
6 plurality of spans including two sub-spans on which traffic travels in  
7 opposite directions on a plurality of channels, each of said sub-spans  
8 coupled to a receiving side and a transmitting side of ports on two  
9 different ones of said nodes, said plurality of channels in each direction  
10 including a set of working channels and a set of protecting channels; and  
11 responsive to said protection switch, programming the receiving side of those of  
12 said ports that are coupled to operable sub-spans so that their protection  
13 channels have programmed thereon the connection configuration of the  
14 working channels programmed on the opposite direction sub-spans of  
15 said failed span.

1 47. The method of claim 46, where said programming includes:  
2 each of said node, selecting from a storage of the connection configurations of  
3 the working channels of each of said spans the connection configuration  
4 of the working channels programmed on said failed span.

1 48. The method of claim 46, further comprising:  
2 storing, prior to said indicating, in each of said plurality of networks  
3 information identifying the connection configurations of the working  
4 channels of each of the spans not directly connected to that network  
5 element.



- 1 49. The method of claim 48, further comprising:  
2 communicating, prior to said storing, between said plurality of network  
3 elements said information.
- 1 50. The method of claim 46, further comprising:  
2 responsive to a correction of said failure, indicating a protection un-switch; and  
3 responsive to said protection un-switch, reprogramming the receiving side of  
4 those of said ports that were programmed responsive to said protection  
5 switch to return them to their state prior to the protection switch.
- 1 51. The method of claim 50, wherein the state prior to the protection switch  
2 includes a connection configuration programmed on the protecting channels of a first of  
3 said spans that does not mirror a connection configuration programmed on the working  
4 channels of said first span.
- 1 52. The method of claim 46, wherein said ring network is a BLSR ring.
- 1 53. The method of claim 46, wherein the same connection configuration must be  
2 programmed on each of said sets of working channels.
- 1 54. The method of claim 46, wherein the same connection configurations must be  
2 programmed on the set of working channels of both sub-spans of any given one of said  
3 spans, and wherein the connection configurations programmed on the sets of working  
4 channels of two different ones of said spans differ.
- 1 55. The method of claim 46, wherein the connection configurations programmed on  
2 the sets of working channels of two different ones of said spans differ, and wherein the  
3 connection configurations programmed on the set of working channels of each of the  
4 sub-spans of at least one of said spans differ.
- 1 56. The method of claim 46, wherein the same connection configuration must be  
2 programmed on the set of working channels of both sub-spans of any given one of said  
3 spans.
- 1 57. A machine-readable medium providing instructions that, when executed by a set  
2 of one or more processors, cause said set of processor to perform operations  
3 comprising:

4 receiving, at a node of a ring network, a first message indicating a protection  
5 switch, wherein said ring network operates on a plurality of network  
6 elements that participate as nodes of said ring network and that are  
7 connected by a plurality of spans to form a ring, each span including two  
8 sub-spans on which traffic travels in opposite directions on a plurality of  
9 channels, said plurality of channels in each direction including a set of  
10 working channels and a set of protecting channels; and  
11 responsive to said first message, reprogramming a receiving side of a first port  
12 of said node coupled to one of said sub-spans so that its protecting  
13 channels have programmed thereon the connection configuration of the  
14 working channels programmed on the opposite direction sub-span of a  
15 span identified by said first message.

1 58. The machine-readable medium of claim 57, wherein said operations further  
2 comprise:  
3 selecting from a storage of the connection configurations of the working  
4 channels of each of said plurality of spans the connection configuration  
5 used for said reprogramming.

1 59. The machine-readable medium of claim 57, wherein said operations further  
2 comprise:  
3 storing, prior to said receiving, the connection configurations of the working  
4 channels of each of the spans not directly connected to said node.

1 60. The machine-readable medium of claim 59, wherein said operations further  
2 comprise:  
3 receiving, prior to said storing, from said plurality of network elements said  
4 connection configurations.

1 61. The machine-readable medium of claim 57, wherein said operations further  
2 comprise:  
3 receiving, at said node, a second message indicating a protection un-switch; and  
4 responsive to said second message, reprogramming said receiving side of said  
5 first port to its state prior to the protection switch.

62. The machine-readable medium of claim 57, wherein said reprogramming also includes reprogramming a receiving side of a second port of said node coupled to the other direction sub-span of the ring relative to said first port, so that the protecting channels on that sub-span have programmed thereon the connection configuration of the working channels programmed on the opposite direction sub-span of the span identified by said first message.

63. The method of claim 57, wherein said ring network is a BLSR ring.

64. A machine-readable medium providing instructions that, when executed by a set of one or more processors, cause said set of processor to perform operations comprising:

in a node of a ring network, storing a connection configuration programmed on working channels on each span of said ring network not directly connected to said node, wherein said ring network operates on a plurality of network elements that participate as nodes of said ring network and that are connected by spans to form a ring, each span including two sub-spans on which traffic travels in opposite directions on a plurality of channels, said plurality of channels in each direction including working channels and protecting channels; and responsive to a protection switch, reprogramming those ports of the node coupled to the sub-spans delivering traffic to that node so that their protecting channels have programmed thereon the connection configuration of the working channels programmed on the opposite direction sub-spans of a span that failed.

65. The machine-readable medium of claim 64, wherein said operations further comprise:

receiving, prior to said storing, from said plurality of network elements said connection configurations.

66. The machine-readable medium of claim 64, wherein said operations further comprise:

responsive to a protection un-switch, reprogramming those ports of the node coupled to the sub-spans delivering traffic to that node so that their

5 protecting channels have programmed thereon their state prior to the  
6 protection switch.

1 67. The machine-readable medium of claim 66, wherein said reprogramming  
2 responsive to said protection un-switch includes reprogramming the protecting  
3 channels on a receiving side of two ports of the node with different connection  
4 configurations.

1 68. The machine-readable medium of claim 64, wherein said reprogramming  
2 includes reprogramming the protecting channels on a receiving side of two ports of the  
3 node with different connection configurations.

1 69. The method of claim 64, wherein said ring network is a BLSR ring.

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